



Vietnam National University, Ho Chi Minh City
University of Technology
Faculty of Computer Science & Engineering

Office for International Study Programs
Capstone Project

A Campus Navigation System on Android Platform

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01. Overviews





Images from BK-OISP

The students participated in the competency assessment exam at HCMUT

Overviews



Outdoor + Indoor

Overviews

Outdoor navigation

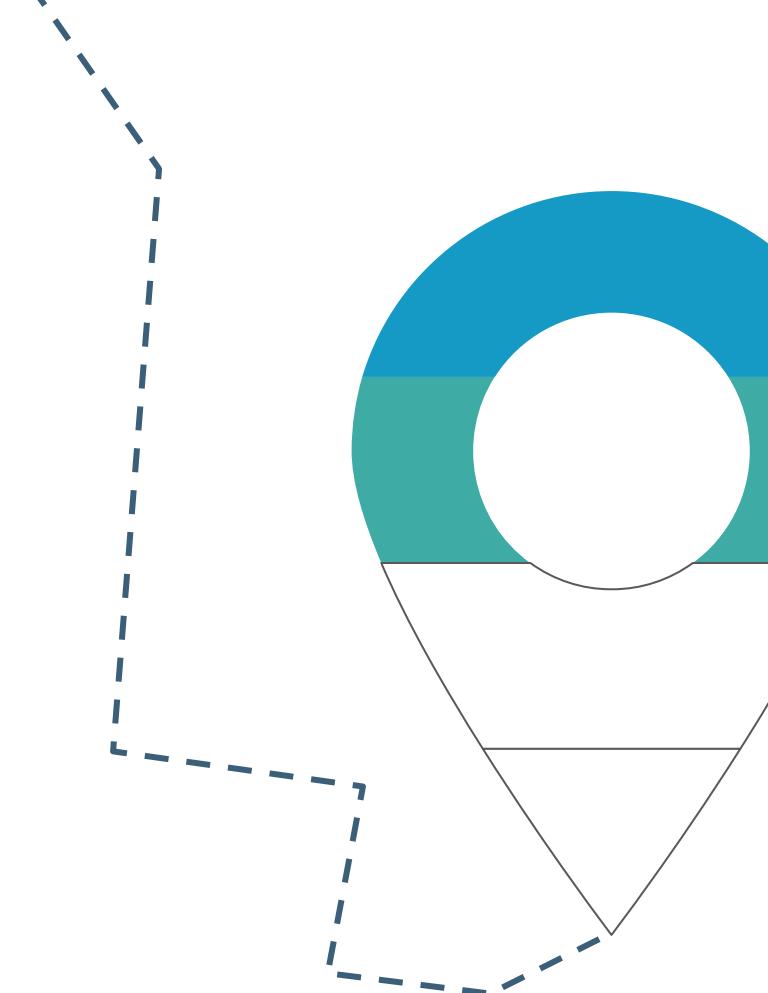


Indoor navigation



MetaMap system

02. System Introductions



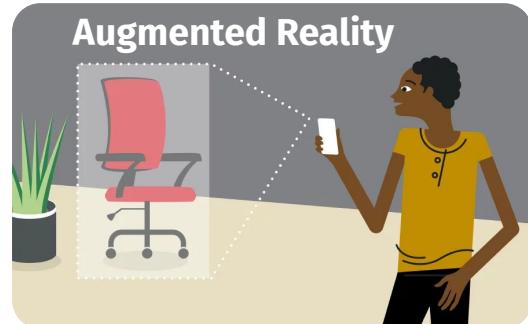
Indoor Navigation

Indoor positioning



+

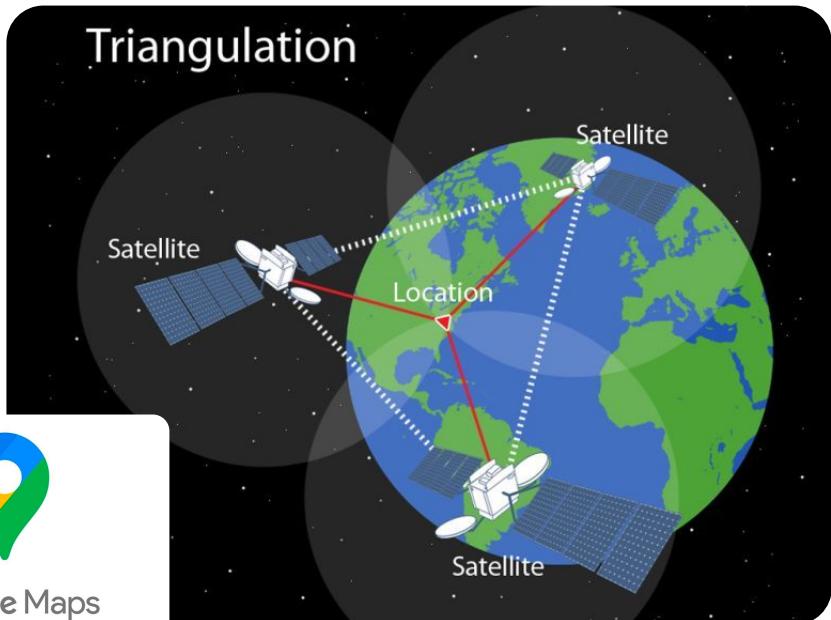
Indoor navigation



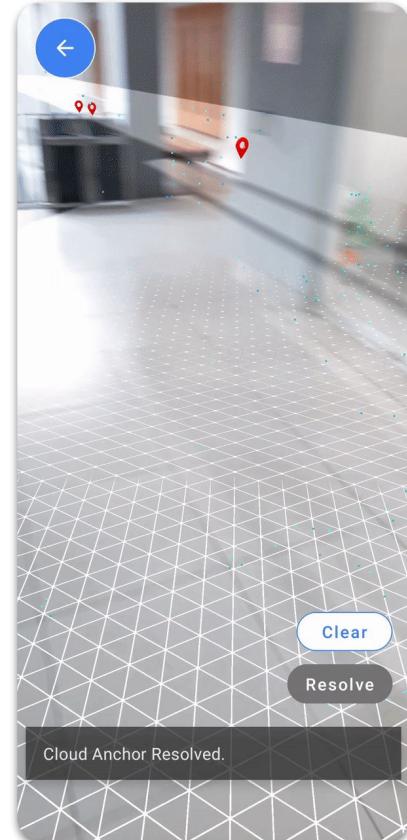
Augmented Reality

Using GPS

- Perform well in outdoor environments
- Have low accuracy in indoor environments



Using Augmented Reality



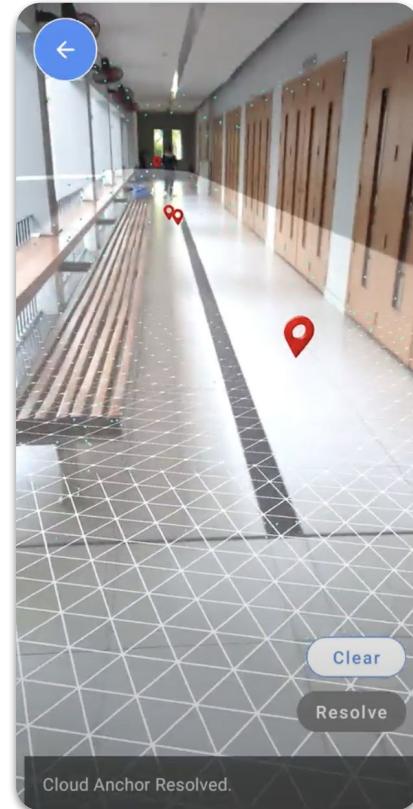
Using AR to for navigations in HCMUT

Using Augmented Reality

- Need a powerful device to scan environments
- The environments is unstable
- Always open camera, Drain battery



ARCore



Using AR for navigations in HCMUT

03. System Analysis

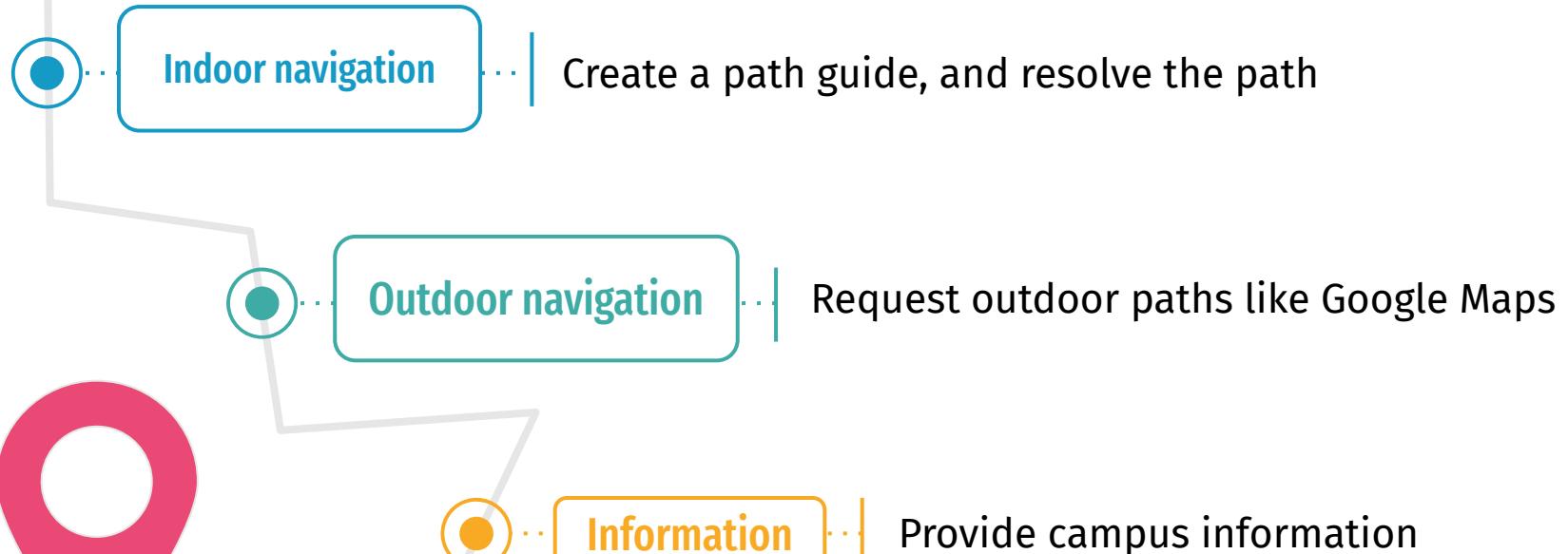


Requirements

Non functional
and functional requirements



Functional Requirements



Non-Functional Requirements



Accuracy

A nice navigation experience can be have at an accuracy of 1 to 5 meters.



Cost-effective

Infrastructure is necessary.
The less, the better.



Offline

Support users to access information when there is no network

Solution

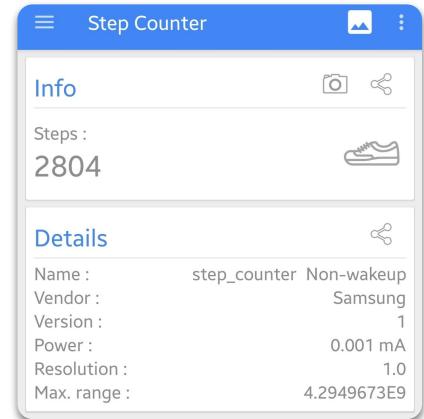
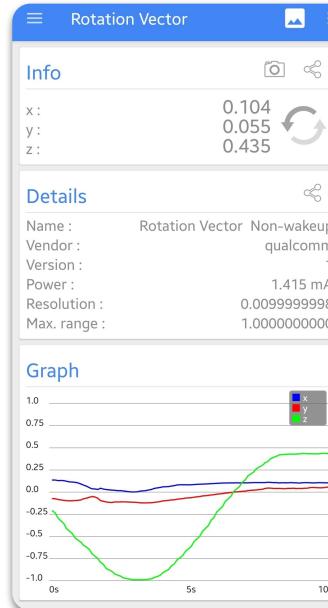
Indoor navigation

Sensor Fusion

Using **Android SensorManager**
to get sensor data and get the angle of
rotation about the **z-axis**

Distance = The number of steps \times Stride length

- More easy to implement
- Cost-effective
- Accuracy



```

// Get the rotation matrix form rotation vector sensor
val rotationMatrix = FloatArray( size: 9)
SensorManager.getRotationMatrixFromVector(rotationMatrix, event.values)

// Calculate Euler angles based on the rotation matrix
val orientation = FloatArray( size: 3)
SensorManager.getOrientation(rotationMatrix, orientation)

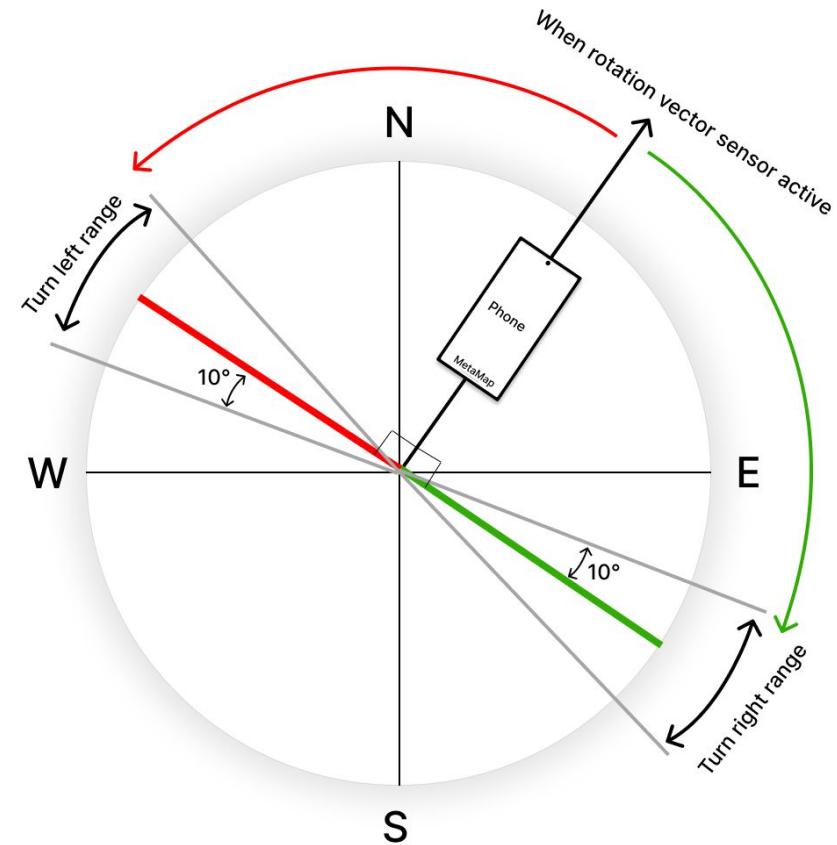
// Get the direction of the device relative to the magnetic North (in degree)
val direction = Math.toDegrees(orientation[0].toDouble()).toInt()

when (direction) {
    // The direction is in the first and second quadrant
    in 0 .. <= 90, in -90 .. <= 0 -> {
        leftAngle = direction - 90
        rightAngle = direction + 90
    }

    // Third quadrant
    in -180 .. <= -90 -> {
        leftAngle = direction + 270
        rightAngle = direction + 90
    }

    // Forth quadrant
    in 90 .. <= 180 -> {
        leftAngle = direction - 90
        rightAngle = direction - 270
    }
}

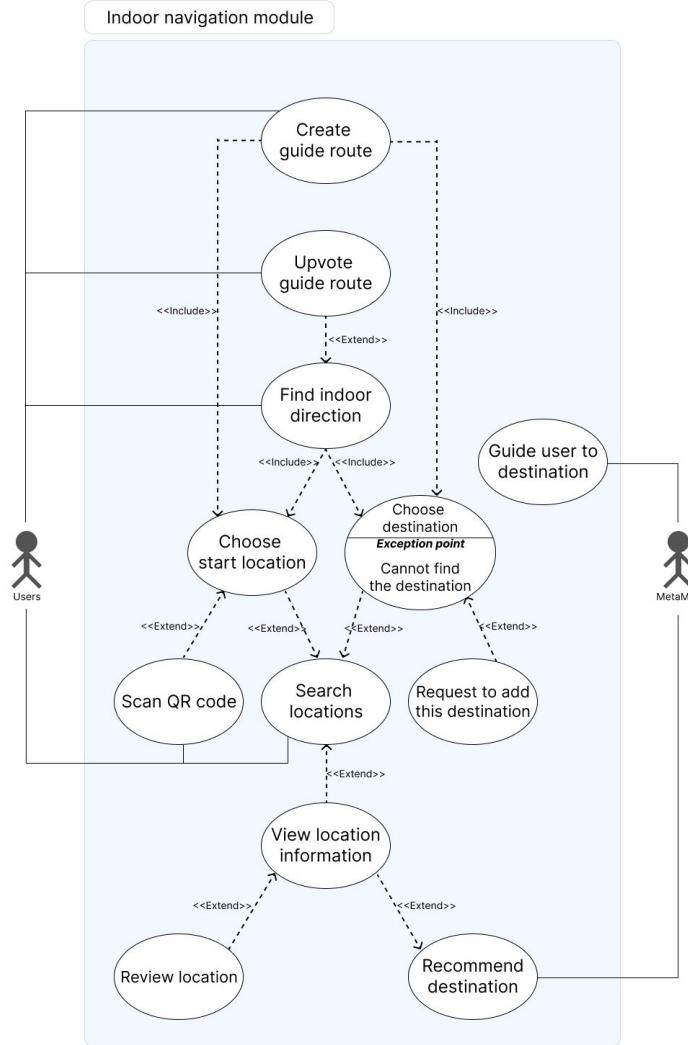
```



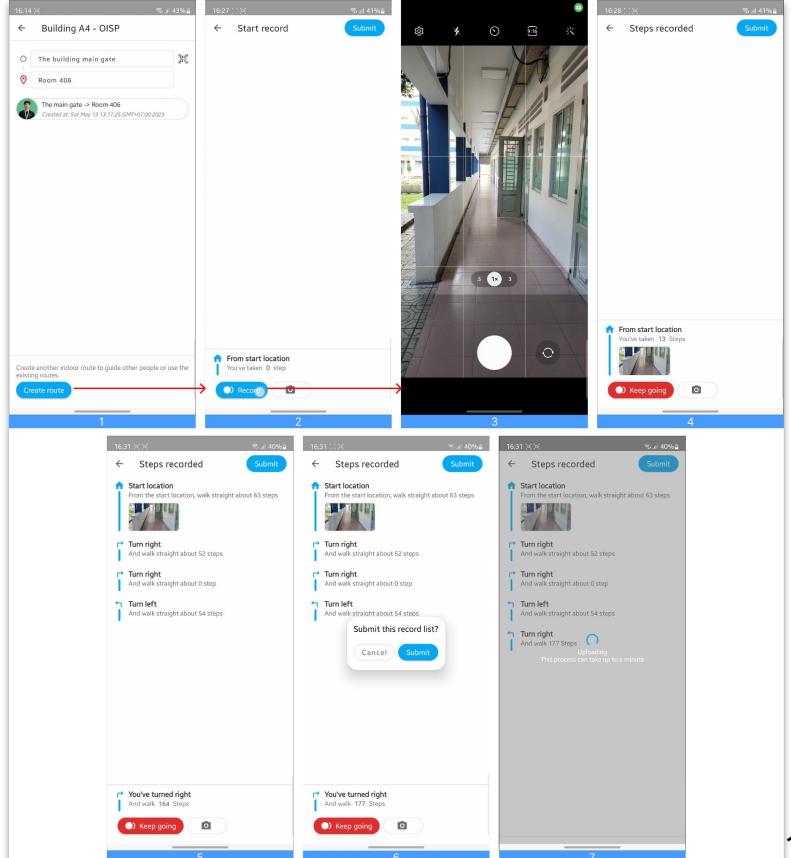
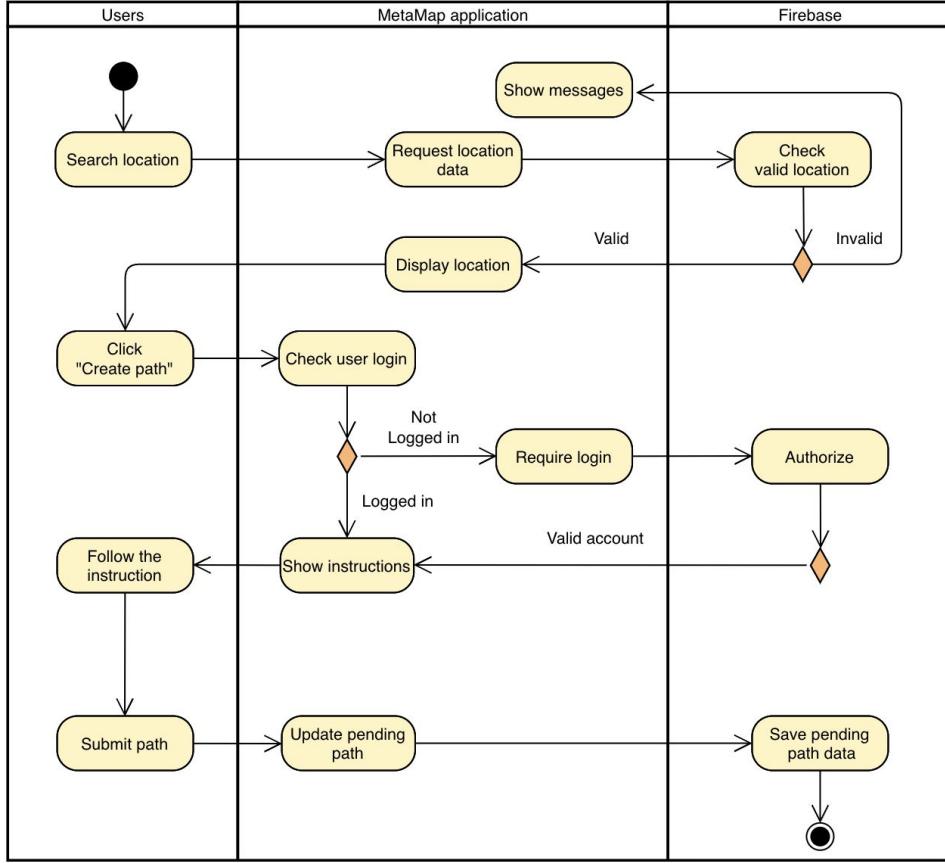
Rotation angle calculations in MetaMap

Use cases

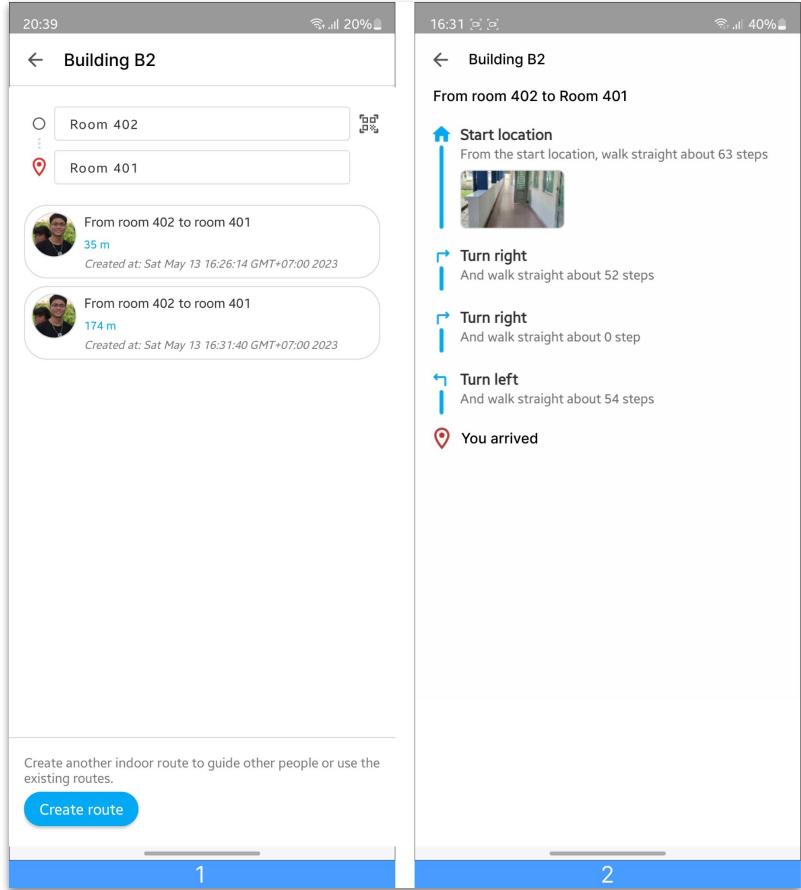
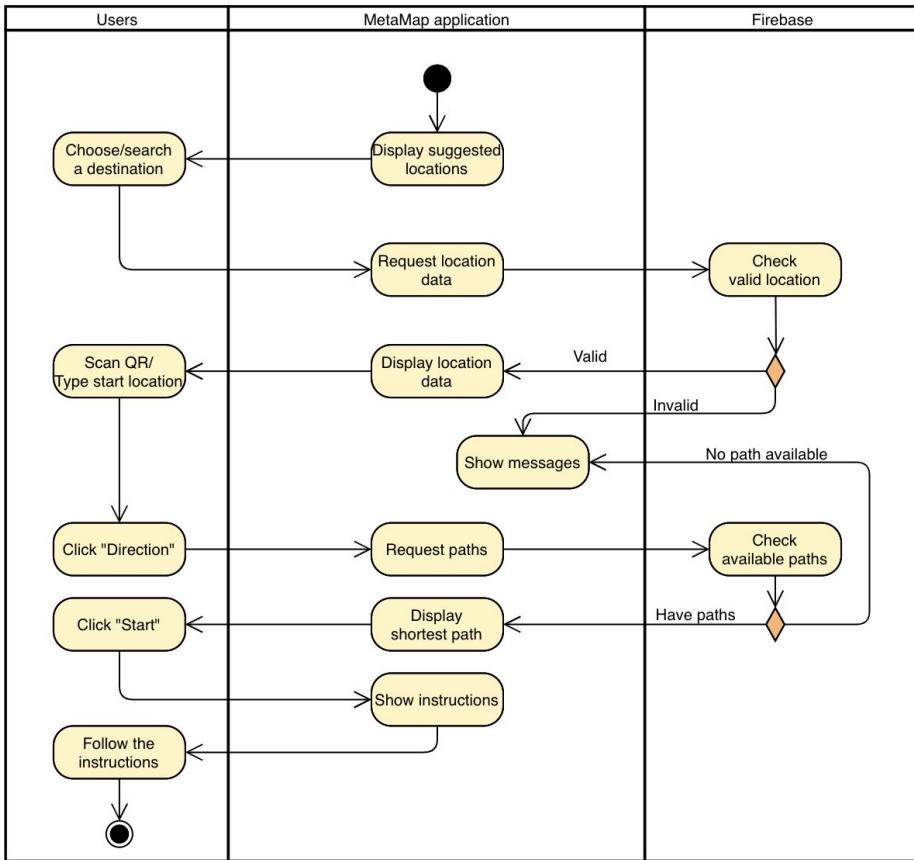
Indoor navigation



Create paths

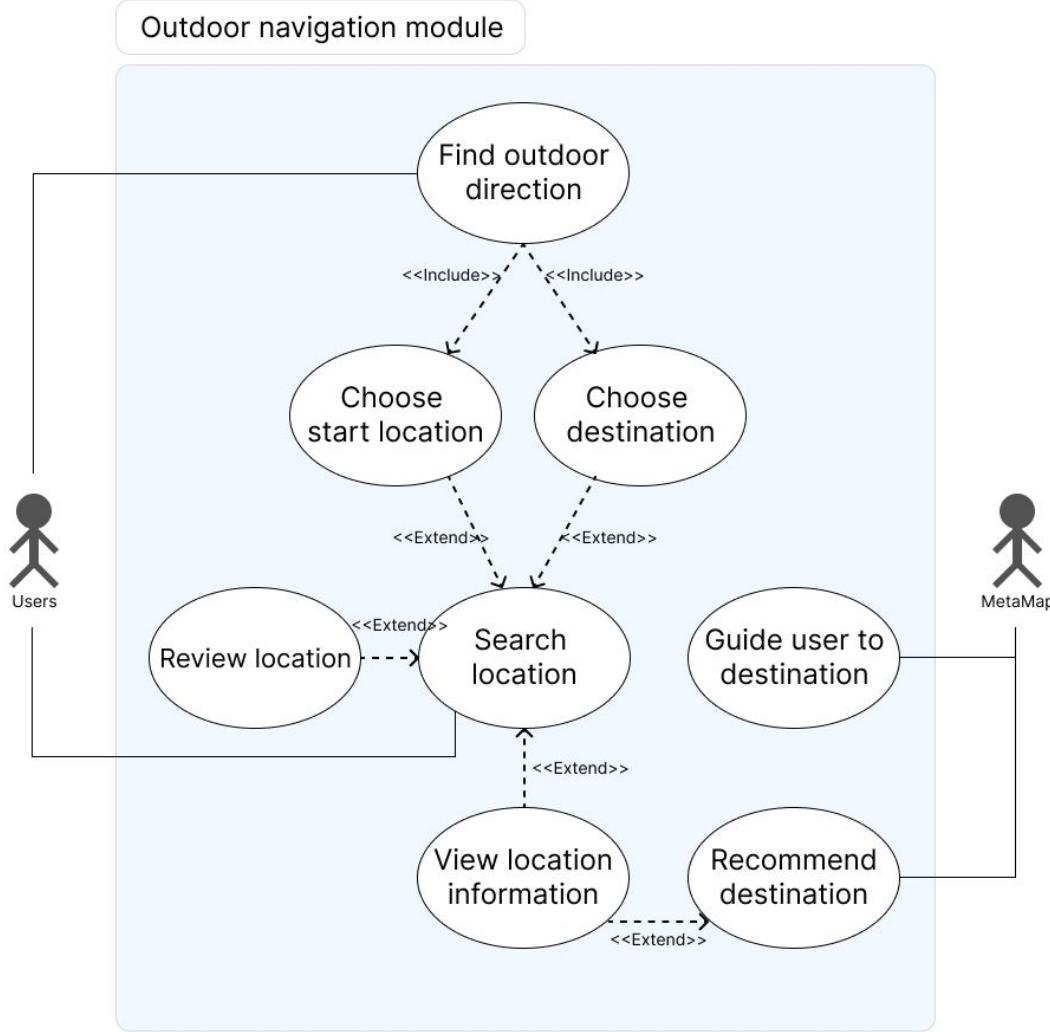


Resolve paths

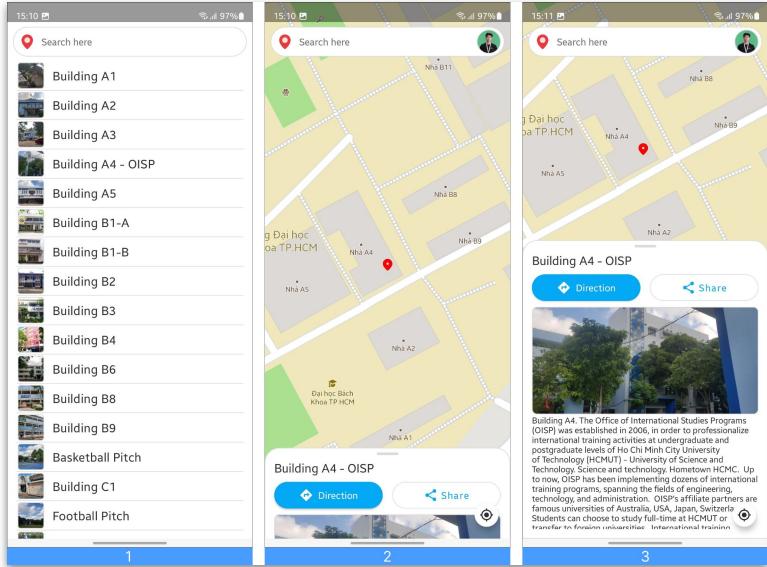


Use cases

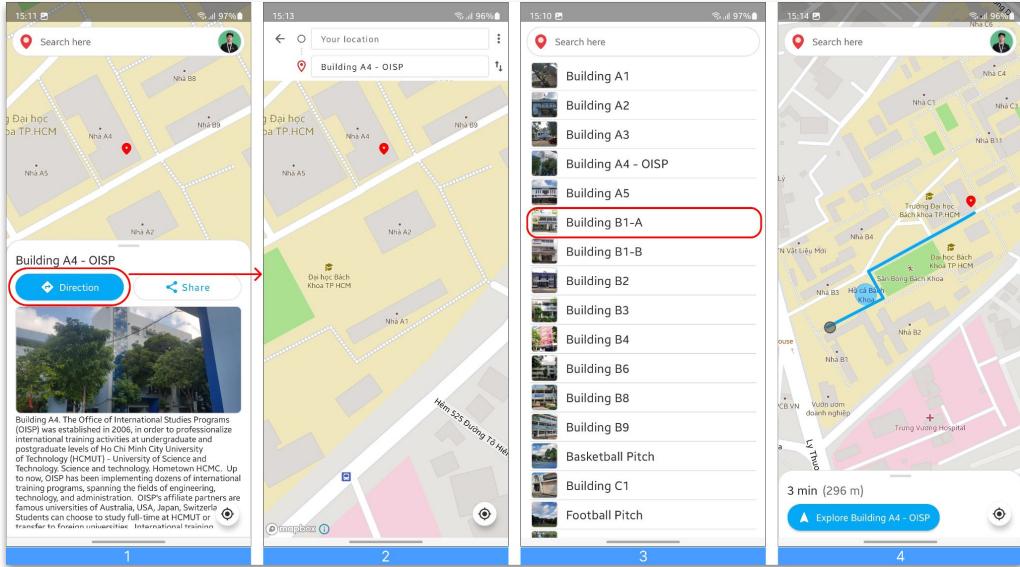
Outdoor navigation



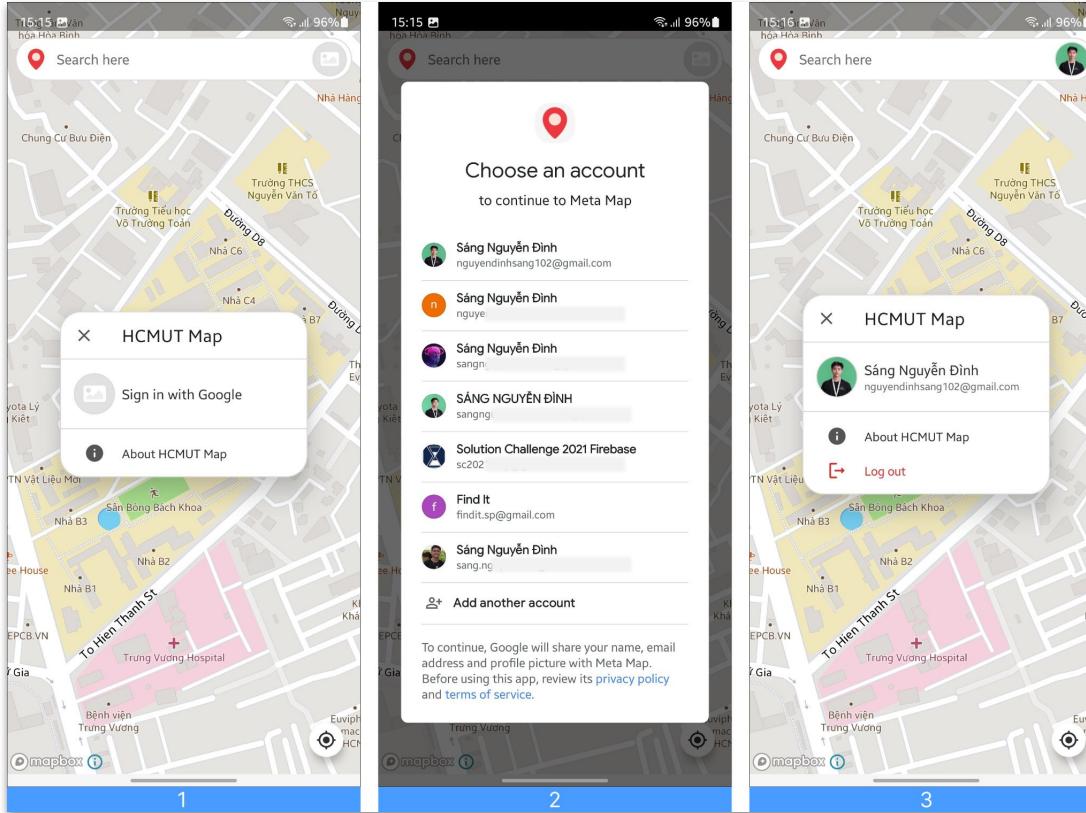
Locate a building



Request outdoor paths



Authentication

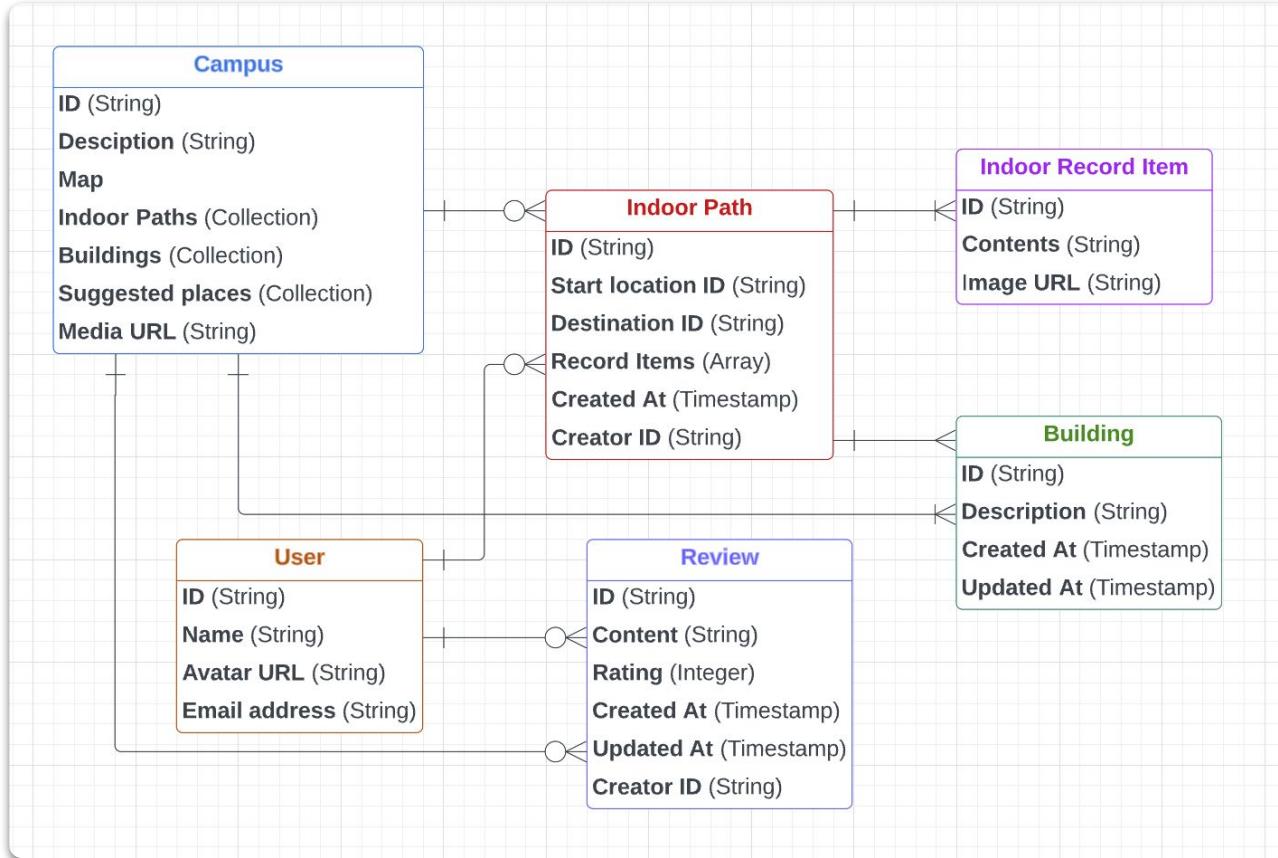


04.

Database Designs



Database designs



sc2022-find-it

	campus		hcmut
+ Start collection	+ Add document	+ Start collection	
campus	chobenthanh	entertainmentVenue	
review		hcmutMapUser	
user	hcmut	indoorPath	
		service	
		suggestedPlace	
		+ Add field	
		address: "268 Ly Thuong Kiet Street, Ward 14, District 10, HCM City"	
		campusId: "hcmut"	
		campusName: "Ho Chi Minh City University of Technology"	
		mapLink: "https://firabasesstorage.googleapis.com/v0/b/sc2022-find-it.appspot.com/o/hcmut%2Fcampus%2FDHBC_HCM-Catalogue-2015-1024x639.jpg?alt=media&token=5511ea6e-1ad2-466e-b5f7-29d90e1048a2"	
		mapSource: "Ho Chi Minh City University of Technology"	

+ Start collection	+ Add document	+ Start collection
entertainmentVenue		path
hcmutMapUser		
indoorPath	a4	+ Add field
service	>	
suggestedPlace		
+ Add field		
address: "268 Ly Thuong Kiet Street, Ward 14, District 10, HCM City"		
campusId: "hcmut"		
campusName: "Ho Chi Minh City University of Technology"		
mapLink: "https://firabasesstorage.googleapis.com/v0/b/sc2022-find-it.appspot.com/o/hcmut%2Fcampus%2FDHBC_HCM-Catalogue-2015-1024x639.jpg?alt=media&token=5511ea6e-1ad2-466e-b5f7-29d90e1048a2"		
mapSource: "Ho Chi Minh City University of Technology"		
		This document has no data

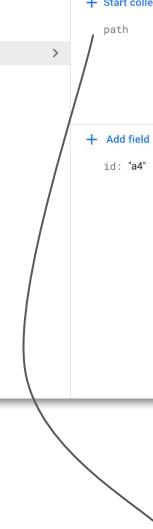
More in Google Cloud

a4 > path > 402-410

+ Start collection	+ Add document	+ Start collection
path	402-401	path
	402-410	
	gate1-401	
	gate1-402	
	gate1-406	
	gate1-407	

+ Add field

This document has no data



More in Google Cloud

402-410 > path > 9794b6a4-d25a-4b0e-9742-c7ebe1d027c6

+ Start collection	+ Add document	+ Start collection
path	9794b6a4-d25a-4b0e-9742-c7ebe1d027c6	

+ Add field

id: "a4"

createdAt: "Sat May 13 16:15:32 GMT+07:00 2023"

pathFolder: "402-410"

record

- 0 {detailContent: "From the ..."}
 - 1 detailContent: "And walk straight about 31 steps"
 - 2 {detailContent: "You have ..."}
 - 3 mainContent: "Turn left"

imageUrl: "https://firebasestorage.googleapis.com/v0/b/sc2022-findingit.appspot.com/o/hcmut%2Fbuilding%2Fa4%2FindoorPath%2F410%2F402-410-4e6ae68e-5609-4b9f-bbf79ba9663ef8c.jpg?alt=media&token=448e3a17-6b22-4365-b3dd-ee9265ba756b"

totalDistance: 23

userName: "Sáng Nguyễn Đình"

userPhotoUrl: "https://lh3.googleusercontent.com/a/AOh14GjCAnZGBiFO4k3TC8XaQ=s96-c"

27

- Collection: "campus"

- Document: "hcmut"

- Field: "address" → "268 Ly Thuong Kiet Street, Ward 14, District 10, HCM City"

- Field: "campusId" → "hcmut"

- Field: "campusName" → "Ho Chi Minh City University of Technology"

- Sub-collection: "buildingInfo"

- Document: "a4"

- Field: "buildingId" → "a4"

- Field: "buildingName" → "Building A4 - OISP"

- Field: "desc" → "Building A4. The Office of International Studies Programs (OISP) was established in 2006, in order to professionalize international training activities at undergraduate and postgraduate levels of Ho Chi Minh City University of Technology (HCMUT) - University of Science and Technology."

- Field: "enableIndoorFeature" → true

- Field: "imageLink" → "https://firebasestorage.googleapis.com/v0/b/sc2022-find-it.appspot.com/o/hcmut%2Fbuilding%2FA4.jpg?alt=media&token=09788484-415c-455e-bd9b-e399306a1308"

- Field: "latitude" → 10.773385891429179

- Field: "longitude" → 106.66009900282725

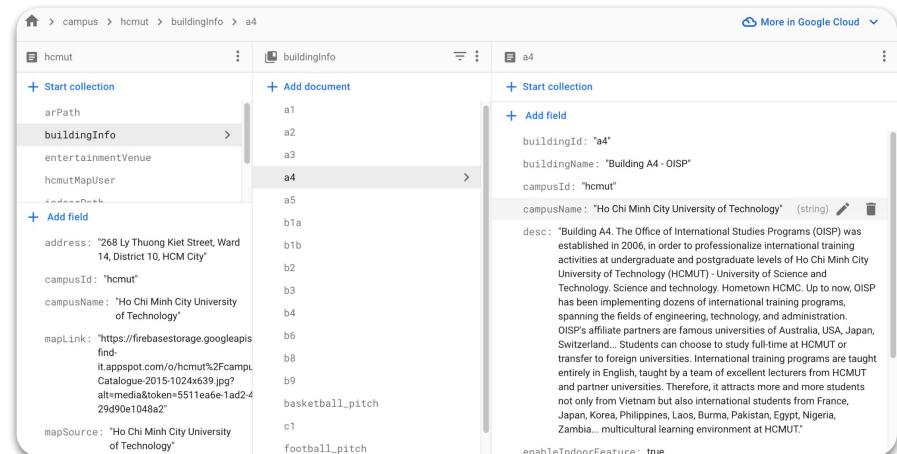
- Field: "reviewNum" → 120

- Field: "rooms" → listOf("401", "402", "403", "404", "405", "406", "407", "408", "409", "410")

- Field: "starNum" → 4.9

- Document: "a1"

- ...

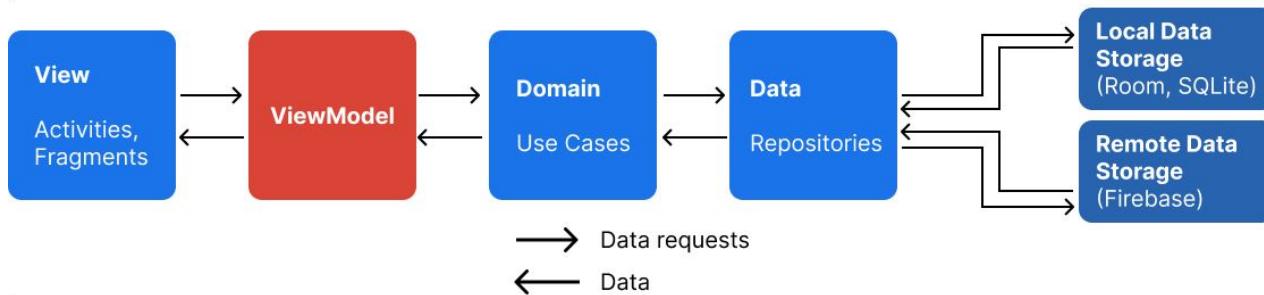


A MetaMap database structure to organize the information about building A4 in Cloud Firestore

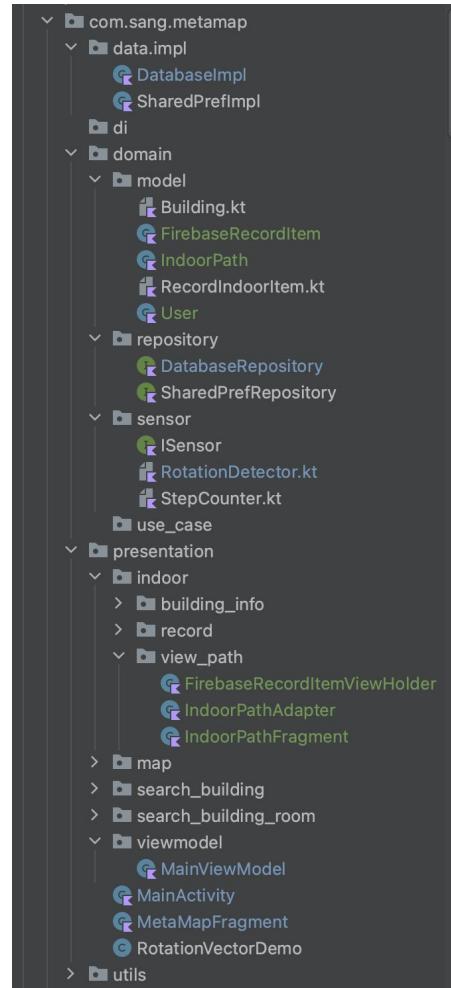
05. System Architectures



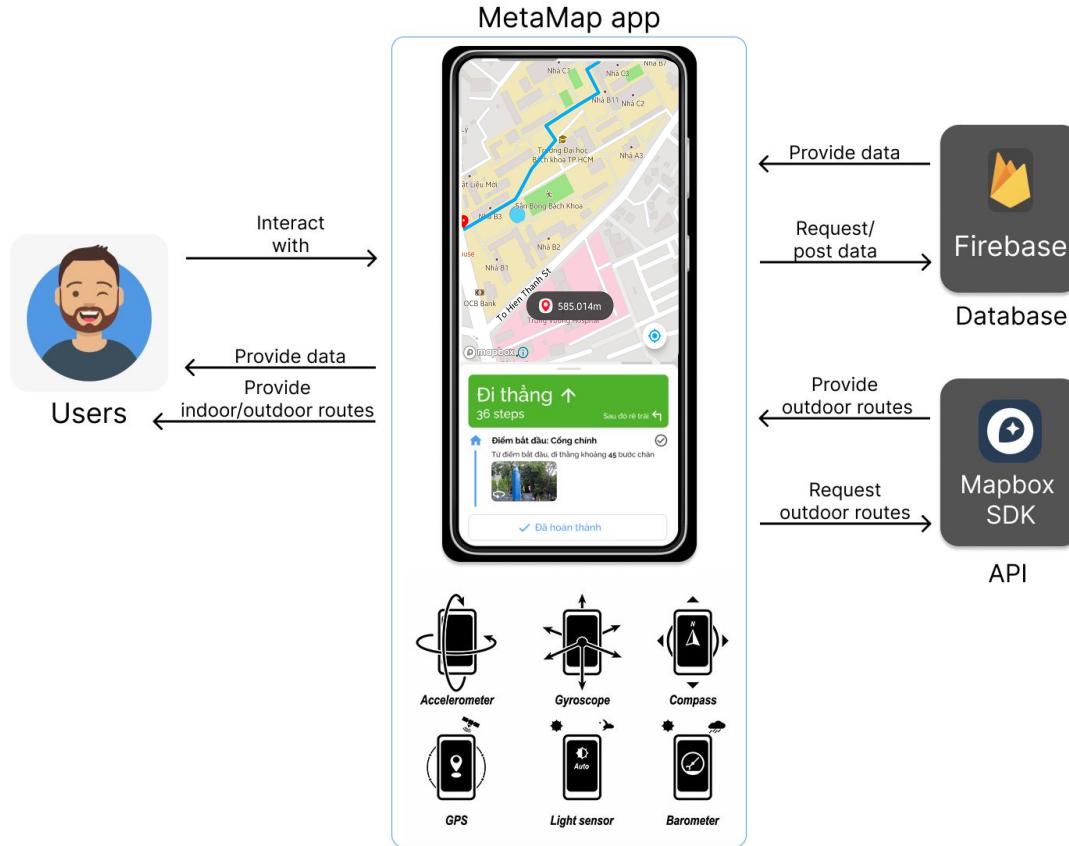
MetaMap application architectures



Model-View-ViewModel Architectures in Android

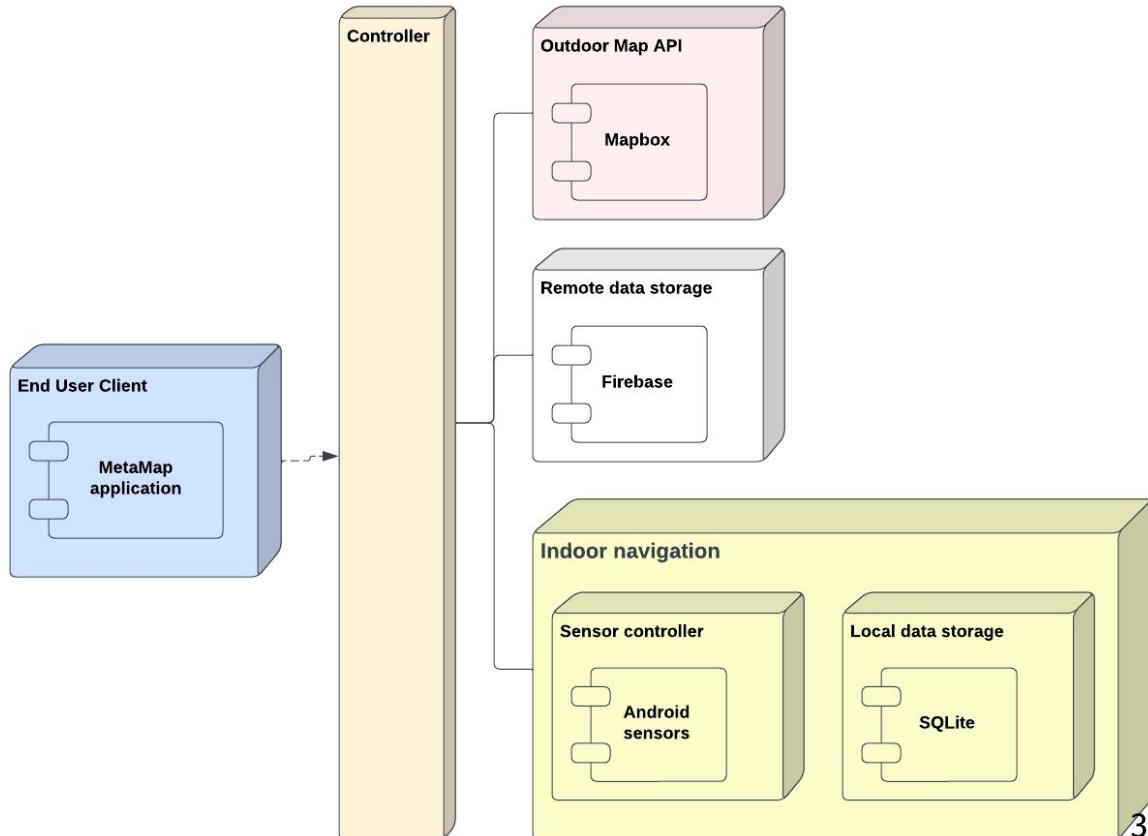


MetaMap system architectures



Deployment diagrams

- **Controller:** A MetaMap app component to connect to other components.
- **Indoor navigation:** The component helps to guide users in indoor environments.
- **Outdoor Map API:** The component helps to guide users in outdoor environments.
- **Remote data storage:** The database built on Firebase.



06. Demo





Authentication



Outdoor navigation



Indoor navigation

16:14

← Building A4 - OISP

The building main gate

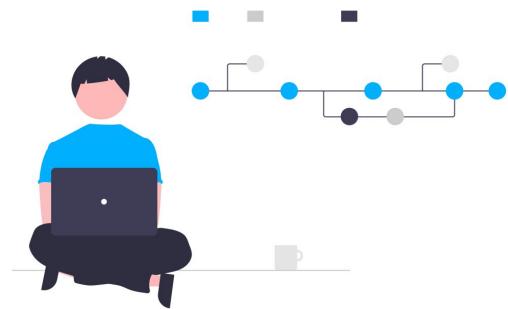
Room 406

The main gate -> Room 406
Created at: Sat May 13 13:17:25 GMT+07:00 2023

Create another indoor route to guide other people or use the existing routes.

Create route

07. Testings



Unit tests + API testings

```
@Test
fun `test updateTurnAngle for positive direction in first and second quadrant`() {
    val direction = 45
    updateTurnAngle(direction)

    assertEquals( expected: -45, leftAngle)
    assertEquals( expected: 135, rightAngle)
    assertTrue(turnAnglesUpdated)
}

@Test
fun `test updateTurnAngle for negative direction in first and second quadrant`() {
    val direction = -60
    updateTurnAngle(direction)

    assertEquals( expected: -150, leftAngle)
    assertEquals( expected: 30, rightAngle)
    assertTrue(turnAnglesUpdated)
}

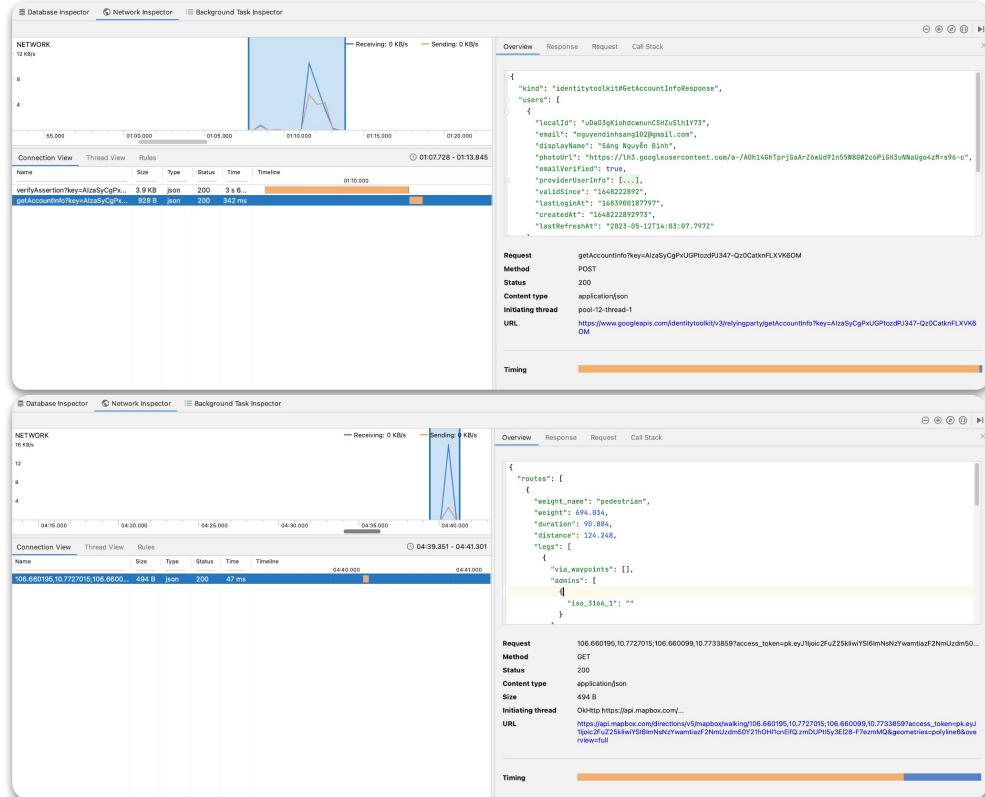
@Test
fun `test updateTurnAngle for direction in third quadrant`() {
    val direction = -120
    updateTurnAngle(direction)

    assertEquals( expected: 150, leftAngle)
    assertEquals( expected: -30, rightAngle)
    assertTrue(turnAnglesUpdated)
}

@Test
fun `test updateTurnAngle for direction in fourth quadrant`() {
    val direction = 160
    updateTurnAngle(direction)

    assertEquals( expected: 70, leftAngle)
    assertEquals( expected: -110, rightAngle)
    assertTrue(turnAnglesUpdated)
}
```

Unit tests for calculating rotation angles



Authentication API & Outdoor API testings

User Acceptance Testings

Functional Testings

Test Case: Guide Path Submission

- Description: Validate the ability to submit completed guide paths to the MetaMap database.
- Steps:
 - Start the MetaMap application.
 - Navigate to a destination within the building using a guide path.
 - Upon reaching the destination, choose the option to submit the completed guide path.
 - Verify if the guide path is successfully submitted to the MetaMap database.
- Expected Result: MetaMap should provide the functionality to submit completed guide paths, allowing other users to benefit from pre-established and verified routes within the building.

User Acceptance Testings

Non-Functional Testings

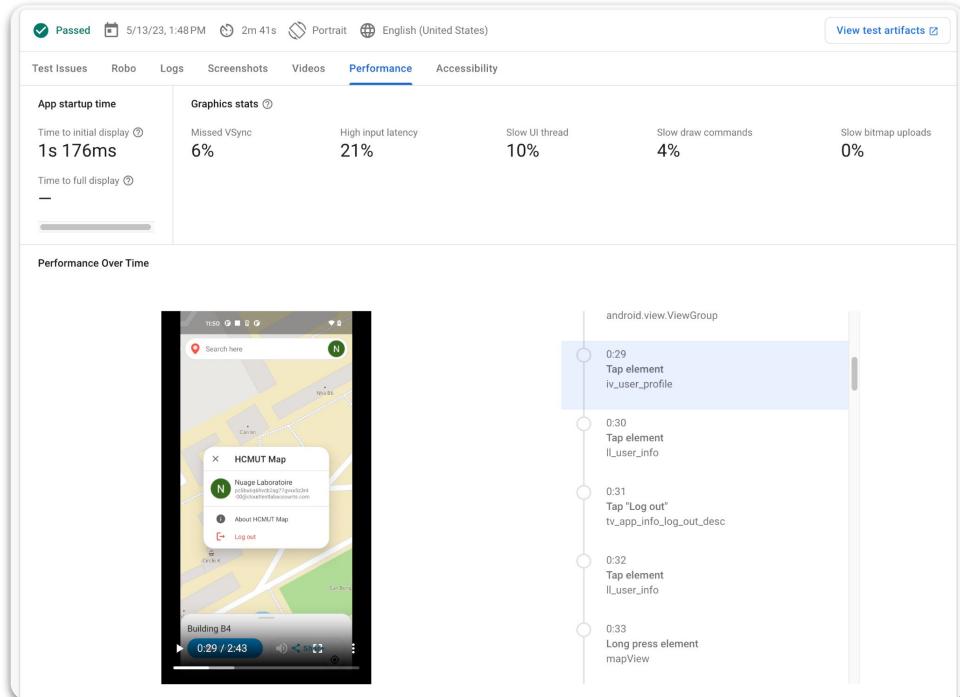
Security: Verify only sign-in users can upload data to the database

Test Case: Verify user cannot upload any data without signing in

- Preconditions: User is not signed in.
- Steps:
 - Attempt to upload data to Cloud Firestore without signing in.
- Expected Result:
 - The upload operation should fail.
 - An error message or prompt should be displayed indicating that the user needs to sign in to upload data.

Automation Testings

The author used
Firebase Test Lab to perform
the automation testing on
MetaMap



User Testings

The author used **Firebase App Distribution** to send MetaMap application to users, and get their feedbacks

The screenshot shows the release details for version 1.0 of the MetaMap application. It includes the release date (May 28, 2023), the number of testers invited (5), accepted (4), downloaded (4), and the count of feedback (0). Below the stats, there is a message from the tester: "Hello, I have just released the first version of the meta ...". At the bottom, there are buttons for 'Copy', 'Download', and 'Delete'. The 'Release notes' tab is currently selected, showing the message: "Hello, I have just released the first version of the meta map application, a navigation application for HCMUT, please download and try it out. Sincerely thank you." The 'Tester feedback' tab is shown as BETA.

1.0 (1)

May 28, 2023 at 5:58:26 PM UTC+7

Invited 5 Accepted 4 Downloaded 4 Feedback 0

Hello, I have just released the first version of the meta ...

[Copy](#) [Download](#) [Delete](#)

Testers [Release notes](#) [Tester feedback \(BETA\)](#)

Hello, I have just released the first version of the meta map application, a navigation application for HCMUT, please download and try it out.
Sincerely thank you.

- The outdoor map is useful, navigate building easily
- Indoor feature is quite accurate but still hard to use
- Users want the outdoor map to be more interactive

08. Conclusions



Results

- MetaMap successfully offers **two essential features**: outdoor navigation and indoor navigation.
- **Outdoor Navigation**: MetaMap enables users to locate buildings on the HCMUT map and provides guided paths for reaching their desired destinations with a beautiful UI.
- **Indoor Navigation**: MetaMap introduces a create-resolve mechanism with a high accuracy, allowing users to create indoor paths for others to follow.
- **Utilizing a cloud database** enhances accessibility. The integration of a sign-in option improves database security.
- **Cost-effective**: Users only need their phones.
- **Offline view**: When the network is weak, users can still access essential features.

Improving points & Future works

- **UI/UX Enhancement:** MetaMap indoor navigation feature requires further improvement in terms of user experience to provide a more seamless and intuitive interface.
- **Floor Change Detection:** Research and experimentation are necessary to develop an automatic floor change detection mechanism, as the current version of MetaMap only supports recording indoor paths within a single floor.
- **Enhanced HCMUT Mapping:** MetaMap should offer more customized content to users, allowing for efficient interaction within the map.

References

- [1] Nguyen Dinh Sang, Nguyen Quoc Viet, Huynh Minh Tri. (2022). Find It - an indoor navigation system using Augmented Reality. <https://github.com/SANGNGUYEN24/find-it>, Global Top 50 Solution Challenge 20 access date 20/11/2022.
- [2] Future lab, *The future of indoor positioning*,
<https://futurelab.assaabloy.com/en/the-future-of-indoor-positioning/>, access date 11/01/2023
- [3] Ho Chi Minh City University of Technology, <https://iro.hcmut.edu.vn/tin-tuc/ban-do-truong-dai-hoc-bach-khoa?lang=vi>, access date 11/01/2023
- [4] Mautz, Rainer. (2009). Overview of Current Indoor Positioning Systems. Geodesy and Cartography. 35. 18-22. 10.3846/1392-1541.2009.35.18-22, access date 20/10/2022
- [5] Verma, Shivam & Omanwar, Rohit & Vidhyadharan, Sreejith & Meera, G. (2016). A smartphone based indoor navigation system. 345-348. 10.1109/ICM.2016.7847886, access date 20/11/2022
- [6] Gregory Blue (2016), *What makes wayfinding in hospitals so difficult*,
<https://www.linkedin.com/pulse/what-makes-wayfinding-hospitals-so-difficult-gregory-blue/>, access date 11/01/2023
- [7] Crowdconnected. (2022). Indoor Positioning Technology Review 2022, <https://www.crowdconnected.com/blog/indoor-positioning-technology-review-2022/>, access date 20/10/2022
- [8] Situm. (2022). Indoor positioning and indoor navigation, <https://situm.com/en/blog-eng/indoor-positioning/indoor-positioning-and-indoor-navigation/>, access date 20/10/2022

Thank you!